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PRODUCTION OF LOW OR FREE FAT YOGHURT

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ABSTRACT: *Effect of adding different levels of inulin on chemical, rheological and sensory properties of yoghurt was investigated. Milk fat was replaced with inulin at the rate of 33,67 and 100%. The experimental yoghurt was compared with control yoghurt produced from whole milk adjusted to 3%fat. The chemical composition, pH, titratable acidity, syneriss, penetration, viscosity, total count, coliform, yeast& mould and organoleptic properties were evaluated in resultant yoghurts when fresh and after 5,10 and 15days of storage at refrigerator. Addition of inulin caused a significant decrease in lactose, tittratable acidity, and syneriss while total solids, ash and viscosity were increased. Titratable acidity, synersiss and penetration were decreased during storage of the yoghurt. The yoghurt containing 1% of inulin showed minor difference in sensory characteristics than that of control yoghurt made of whole milk.*

Key words: *Inulin– Yoghurt- Chemical composition – Sensory properties*

INTRODUCTION

Yoghurt is the most popular fermented milk produced in Egypt and worldwide. Its consumption in Egypt has been increased tremendously. The value of yoghurt in human nutrition is based, not only on the nutritive value of the milk from which it is made but also on the beneficial effect of intestinal microflora, improved lactose tolerance, protection against gastrointestinal infections, effective treatment for specific types of diarrhea, improved immunity, cholesterol reduction and protection against cancer (Buttriss,1997).

Modification of fat content results in flavour and textural variations, which are important factors for consumer perception and market success. The relationship between fat consumption and heart diseases has been accepted. Consumption of low or non fat dairy products has increased in recongnition of their health benefits and consumers' health problems (Haque and Ji 2003).

Inulin, a carbohydrate-derived fat replacer or dietary fibre, has a gelling capacity with water, and is a functional food additive due to its prebiotic properties (O'Brein *et al.*, 2003). It is not digested in the small intestine, but is fermented in the colon by lactic acid bacteria such as yoghurt starter cultures. Consequently, inulin promotes the growth of healthy bacteria and enhances calcium & magnesium absorption and reduce the level of cholesterol and serum lipids (Dello Staffolo *et al.*, 2004 and Ohr 2004). Furthermore, the fermentation of inulin may stimulate the formation of short-

chain fatty acids such as acetate, propionate and butyrate, the latter being the preferred energy substrate for colonocytes (Kruse *et al.*, 1999). Inulin, in water-based foods such as dairy products, when used as a fat replacer, gives a fat-like feel mouth and texture (Zimeri and Kokini 2003).

Functional properties of inulin such as the ability to act as a fat or sugar replacer without adversely affecting flavour (Tungland,2000). The fat-substituting property of inulin is based on the ability to stabilize the structure of the aqueous phase, which creates an improved creaminess mouth feel (Blomsma,1997).

The objectives of this study were to investigate the possibility of using inulin in the manufacture of yoghurt, and study the effect of adding inulin on the chemical, rheological, microbiological and sensory evaluation of yoghurt during storage at refrigerator temperature.

MATERIALS AND METHODS

Materials:-

Fresh cow's milk used in this study was obtained from the herd of Food Technology Research Institute, Ministry of Agriculture (Sakha Experimental station). Inulin was obtained from Ferak berlin. Mixed starter culture (*Lactobacillus delbrueckii* subspp. *bulgaricus* and *Streptococcus salivarius* subspp. *thermophilus)* was obtained from Hansen Laboratories Denmark.

Methods:-

Yoghurt manufacture:-

Four batches of yoghurt were made from fresh cow's milk (3%fat) as follows:-

Control: Cow milk adjusted to 3%fat
T1: Cow milk with 2%fat +1%inulin.
T2: Cow milk with 1%fat +2%inulin.
T3: Cow milk with 0.1%fat +%3inulin.

Inulin was added to warm milk. Milk from all treatments were heated to 85°C for 10min then cooled to 42°C and inoculated with 2%yoghurtstarter culture, dispersed into plastic cups, 200g and incubated at 42°C until pH reachs 4.7. After complete coagulation, All treatments were stored in the refrigerator at 5°C for 15days and examined when fresh and after 5,10 and 15days of storage. Yoghurt were manufactured according to the method of Tamime and Robinson (1985). All experiments were carried out in triplicate.

Chemical analysis:

Total solids and ash of yoghurt were determined according to AOAC (2000). Lactose content of yoghurt was determined according to Barrantes *et al.*, (1994). Fat and titratable acidity of yoghurt were determined according to

Mistry and Hassan (1992). The pH values were measured using a digital pH meter model SA 720 (Orion, U.S.A).

Rheological properties:-

Syneresis was determined by measuring the volume of separated whey (ml whey/50ml yoghurt) collected after 30 min at room temperature (Abd-El-Salam *et al.,* 1991). Penetration was measured using a Koehler Pentetrometer as mentioned by El-Shabrawy *et al.*,2002. The viscosity of yoghurt was measured using coaxial cylinder viscometer (Brookfield Engineering labs DV-III Ultra Rheometer and COM1 or COM2 of our host computer).

Microbiological Analysis

Lactic acid bacteria was enumerated according to Elliker *et al.* (1956). Coliforms were enumerated according to Harrigan and McCance (1996) using Violt Red Bile agar media. Mould and yeast were determined according to Standard Methods for Examination of Dairy Products (APHA,1992).

Sensory evaluation:-

Yoghurt samples were assessed according to Nelsons and Trout (1981) when fresh and after 5,10 and 15days of storage by ten panelists of staff members at Department of Dairy Science, Food Technology Instutite.

Statistical analysis:-

Statistical analysis was performed according to SAS Institute (1990) using Liner Model (GLM). Duncans'multiple range was used to separate among means of three replicates of samples.

RESULTS AND DISCUSSION

Table (1) revealed that the percentage of total solids and ash reached the highest and the lactose % decreased to the lowest in all stored yoghurt treatments and especially in the yoghurt manufacterd with added above 1% of inulin. The titratable acidity was the highest in yoghurt samples stored for 15 days in all treatments. Control treatment gave highest titratable acidity values in fresh samples compared to those, with added inulin (Tables 1,5).

From the same table, the total solids content were 12.91% and 14.40% for control treatment in zero time and after storage for 15 days for 3% inulin respectively. During storage period of yoghurt a pronounced decrease significant ($P \leq 0.05$) in lactose contents was observed. This was reported by (Renner, 1986) and mainly due to its utilization by lactic acid bacteria as a main source for energy (Rasic&Kurmann,1978). Also, there was slightly increase in ash content during the storage, due to the changes in total solids

content (El-Nagar & Shenana, 1998). Increase in acidity content during storage of yoghurt were also reported by (El-Shibiny *et al.*, 1979).

Table (1) : Chemical characteristics and Titratable acidity of yoghurt as affected by inulin content.

Properties	Treatments*	Storage periods			
		Fresh	5days	10days	15days
Total Solids(%)	Control	12.91	13.14	13.36	13.45
	T1	13.34	13.52	13.69	13.80
	T2	13.61	13.73	13.95	14.12
	T3	13.83	13.98	14.28	14.40
Fat (%)	Control	3.0	3.1	3.2	3.3
	T1	1.8	1.9	2.0	2.1
	T2	1.0	1.1	1.2	1.2
	T3	0.1	0.1	0.2	0.2
Lactose (%)	Control	3.31	3.09	2.92	2.63
	T1	3.15	2.91	2.88	2.45
	T2	3.00	2.90	2.80	2.32
	T3	2.81	2.75	2.69	2.09
Ash (%)	Control	0.86	0.88	0.91	0.92
	T1	0.89	0.92	0.94	0.96
	T2	0.93	0.94	0.97	0.98
	T3	0.95	0.97	1.00	1.03
pH	Control	4.68	4.51	4.43	4.36
	T1	4.76	4.66	4.51	4.44
	T2	4.93	4.78	4.67	4.53
	T3	4.99	4.80	4.72	4.61
Titratable acidity (%)	Control	0.88	0.92	0.96	1.01
	T1	0.79	0.81	0.83	0.86
	T2	0.75	0.78	0.80	0.83
	T3	0.70	0.72	0.75	0.78

*Control: Cow milk with (3%fat). T1: Cow milk with (2%fat).
T2: Cow milk with (1%fat). T3: Cow milk with (0.1%fat).

The syneresis of yoghurt was affected by the concentrations of inulin used as shown in table (2). Increased separation of whey from the yoghurt was observed in the lowest level of inulin, which may be due to the higher

added inulin percent. Treatments revealed that yoghurt syneresis decreased during the interval storge periods. Similar results were reported by Barrants *et al.*, (1994); Omar&Abou El-Nour, (1998) and El-Nagar &Shenana, (1998). On the other hand, the susceptibility to syneresis decreased with adding fibers. Also, the synersis decreased by increasing the fibers level (El-Nagar and Brennan, 2001). Cerning *et al.*(1990) reported that the expolysaccharides reduced syneresis when used in yoghurt.

The penetration readings were inversely related to firmness. Increasing concentrations of inulin in yoghurt treatments lead to decrease peneteration values. Upon storage, the penetration values generally decreased indicating firmness increase. Hess *et al.*, (1997) reported similar observation it was as suggested that they were consistent with a mechanism for shear-induced disruption of the network prevented by inulin associated with the casein matrix Inulin being highly soluble appears to enhance gel matrix.

Table (2) : Syneriss and pentration characteristics of yoghurt as affected by inulin content.

Properties	Treatments*	Storage periods			
		Fresh	5days	10days	15days
Syneresis (ml/50g)	Control	32	30	27	25
	T1	28	25	22	20
	T2	25	23	21	19
	T3	22	20	19	17
Pentration (mm)	Control	35.9	33.4	33.0	30.8
	T1	34.3	32.4	31.2	30.5
	T2	33.0	30.0	29.8	29.3
	T3	32.2	29.6	29.0	28.8

*See table (1)

Viscosity values of yoghurt are shown in Fig (1). All expermints with inulin had higher viscosity throughout the storage period compared to the value of fresh treatment. The increase in viscosity value could be due to the exceptional water binding capacity and ability to enhance the viscosity of inulin (Wang, *et al.*, 1998). Marshall and Rawoson (1999) suggested that it may not be the amount of polysaccharide which is important in affecting the viscosity, but the type of exopolysaccharides and consequently the interaction of the polymer with the milk proteins during the fermentation.

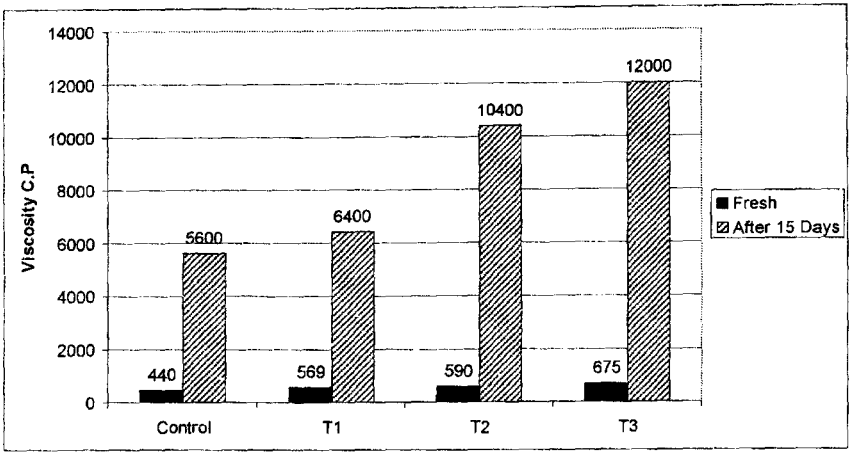

Figure (1) : Viscostity of yoghurt as affected by inulin content.

Data presented in table (3) illustrated that the count of lactic acid bacteria of all treatments with inulin had higher count than the control at any time. Menne *et al.*, (1997) reported that using inulin in the fermented dairy products increase the lactic acid bacterial count. Our results coliform the observation of Gibson and Roberfroid (1995), Roberfroid *et al.*, (1998). El-Nagar and Brennan (2001) and Mehanna *et al.*, (2003) who reported that inulin stimulating the growth of lactic acid bacteria.

All samples were free of coliform bacteria, moulds and yeasts, as a result of high hygienic condition during the preparation and storage period.

Table (3) : Effect of inulin concentration on Lactic acid bacteria, coliform bacteria and yeast & mould of yoghurt during storage periods.

Properties	Treatments*	Storage periods			
		Fresh	5days	10days	15days
LAB	Control	$52x10^4$	$31x10^4$	$70x10^4$	$70x10^4$
	T1	$40x10^4$	$42x10^4$	$44x10^4$	$29x10^5$
	T2	$34x10^4$	$14x10^5$	$11x10^5$	$27x10^5$
	T3	$78x10^4$	$20x10^4$	$51x10^4$	$27x10^5$
Coliform	Control	ND	ND	ND	ND
	T1	ND	ND	ND	ND
	T2	ND	ND	ND	ND
	T3	ND	ND	ND	ND
Yeast & Mould	Control	ND	ND	ND	1x10
	T1	ND	ND	ND	15x10
	T2	ND	ND	ND	28x10
	T3	ND	ND	ND	30x10

*See table (1) LAB=Lactic acid bacteria ND=Not detect

Sensory properties of yoghurt samples are shown in table (4). The highest scores were optained in control group followed by treatment containing 1% inulin. Increasing the levels of inulin negatively affected the flavour scores. Similarly, the addition of inulin influenced the body and texture of the yoghurt samples. No significant differences were found in the appearance score of samples. With respect to general acceptability of the yoghurt samples, control treatment showed the highest score, followed by T1,T2 and T3 yoghurt samples containing 1,2 and 3% of inulin, respectively (Tables 4,6). This was expected as the fat is the main carrier of flavour for many compounds (Plug and Haring, 1993, Ohmes *et al.*, 1998). Ressults emphasized the importance of fat as a flavour modifier. The fat –substituting property of inulin is based on the product's ability to stabilize water into creamy structure, which has an excellent fat-like mouthfeel and is almost taste free (Blomsma,1997).

Table (4) : Sensory properties of yoghurt as affected by inulin content.

Treatments*	Properties	Score	Storage period			
			Fresh	5days	10days	15days
Control	Flavour	45	44	43	42	41
	Body & Texture	30	28	28	27	26
	Apperance	15	14	13	12	11
	Acidity	10	8	8	8	7
	Total	100	94	92	89	85
T1	Flavour	45	43	42	41	40
	Body & Texture	30	28	27	26	25
	Apperance	15	14	13	12	11
	Acidity	10	8	8	8	7
	Total	100	93	90	87	83
T2	Flavour	45	42	40	39	38
	Body & Texture	30	27	26	25	24
	Apperance	15	14	13	12	11
	Acidity	10	7	7	7	6
	Total	100	90	86	83	79
T3	Flavour	45	40	39	38	37
	Body & Texture	30	26	25	25	24
	Apperance	15	13	12	12	11
	Acidity	10	7	7	6	6
	Total	100	86	83	81	78

*See table (1)

Throughout the storage period, slight decrease of scores in all treatments until the end of this period (15days) (Tables 4,6). This may be due to increase in the acidity which affect the rheological properties (El-Nagar and Brennan, 2001, Ibrahim *et al.*, 2003). These results are in agreement with El-Nagar and Brennan, (2001), Mehanna *et al.*, (2003) and Ibrahim *et al.*, (2003).

Table (5) : Statistical analysis of chemical characteristics and titratable acidity of yoghurt as affected by inulin content.

Yoghurt properties	Effect of treatments				
	Multiple comparisons				
	LSD	Control	T1	T2	T3
Mositure (%)	0.8312	B	AB	AB	A
Fat (%)	0.0791	A	B	C	D
Lactose (%)	0.0083	A	B	C	D
Ash (%)	0.0083	D	C	B	A
Titratable acidity (%)	0.0083	A	B	C	D
	Effect of storage period (days)				
	Multiple comparisons				
	LSD	Fresh	5	10	15
Mositure (%)	0.237	C	B	B	A
Fat (%)	0.0791	B	B	A	A
Lactose (%)	0.0083	A	B	C	D
Ash (%)	0.0083	D	C	B	A
Titratable acidity (%)	0.0083	D	C	B	A

*For each effect the different letters in the sam row means the multiple comparisons are different from each other, Letter A is highest mean followed by B,C,....etc.
*Significant at 0.05 level (P≤0.05).

Table (6) : Statistical analysis of sensory properties of yoghurt as affected by inulin content.

Yoghurt properties	Effect of treatments				
	Multiple comparisons				
	LSD	Control	T1	T2	T3
Flavour	0.776	A	B	C	D
Body& Texture	0.776	A	A	B	B
Apperance	N.S	A	A	A	A
Acidity	0.738	A	A	B	B
Total	0.738	A	B	C	D
	Effect of storage period (days)				
	Multiple comparisons				
	LSD	Fresh	5	10	15
Flavour	0.776	A	B	C	D
Body& Texture	0.776	A	AB	B	C
Apperance	0.417	A	B	C	D
Acidity	0.738	A	A	A	B
Total	0.738	A	B	C	D

*For each effect the different letters in the sam row means the multiple comparisons are different from each other, Letter A is highest mean followed by B,C,....etc.
*Significant at 0.05 level (P≤0.05).

CONCLUSION

It could be concluded that yoghurt made from cow's milk with adduig 1% inulin was the most acceptable yoghurt and was not different from the control. Therefore, it is possible to make a good quality yoghurt from cow's milk by adding inulin till to 2%.

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أنتاج زبادى منخفض أو خالى الدسم

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الملخص العربي

يهدف البحث إلى دراسة إمكانية تصنيع الزبادى المنخفض أو خالى الدهن بإستخدام الأنيولين أحد بدائل الدهون. وقد تم تصنيع الزبادى بإستبدال جزئى أو كلى لدهن اللبن بالأنيولين ، حيث تم إستبدال ١% ، ٢ %، ٣% من دهن اللبن البقرى بالأنيولين وقورن الزبادى المعامل بالزبادى الكونترول ٣% دهن لبن . تم تخزين الزبادى الناتج لمدة ١٥يوم على درجة حرارة الثلاجة كما تم تحليله لكلا من الخواص الكيماوية والطبيعية والحسية وأوضحت النتائج أنه بزيادة إضافة الأنيولين إلى اللبن زادت الجوامد الكلية وكذلك الرماد بينما أنخفض محتوى اللاكتوز وكذلك الحموضة للزبادى الطازج ومع تخزين الزبادى زاد محتوى الرماد و الحموضة وكذلك الجوامد الكلية وإنخفض محتوى اللاكتوز . كما أوضحت النتائج أنه بزيادة تركيز الأنيولين إنخفض إنفصال الشرش فى الزبادى كما زادت الصلابة وكذلك اللزوجة بزيادة تركيز الأنيولين فى اللبن. كما زادت أعداد بكتريا حمض اللاكتيك بزيادة تركيز الأنيولين وكذلك بالتخزين . أما التحكيم الحسى فقد حصلت المعاملة ١% أنيولين على درجات مقاربة للكونترول وتلاها المعاملة ٢% انيولين.